

Literacy Specialists in Math Class! Closing the Achievement Gap on State Math Assessments

“The Eliot School plans to have the school library carpeted. The room is in the shape of a rectangle and measures 24 feet by 18 feet. If the carpet costs \$25.75 per square yard including installation, how much will it cost to have the library carpeted?”

—The Massachusetts Comprehensive System: Release of Spring 2002 Test Items

To determine the correct answer to the problem above, students need to know that this question is asking them to convert the measurements of the library from feet to yards by dividing by nine, to find the area of the library by multiplying the base times the height, and to multiply that answer by \$25.75. Those are just the math concepts! A student who is an English language learner must also read and understand that having a room carpeted means putting down a rug that covers the area of a room and that installation is a word for putting the carpet down!

This is a great deal of intellectual activity for anyone, and in Massachusetts, students in sixth and eighth grades have to do this type of thinking for 39 questions as they answer problems on our Massachusetts state math assessment (MCAS). Recognizing the challenges in reading math problems, Dianne and I, Literacy Specialists at Fuller Middle School in Framingham, began working with math teachers to find out exactly what the test was asking students to do, and how we could help students, particularly students in our ELL classes, succeed.

What Do Students Need to Know?

We determined that in addition to knowing math, students need to learn how to read questions like the one above so that they can demonstrate their math knowledge. For open-response questions—three- or four-part questions where students are asked to “explain or show their thinking”—students need to know how to read *all* the parts of the question and write their answers in order to receive full credit. On the math MCAS, there are usually five open-response questions where students are asked to read and solve a multistep problem, showing all their work. These problems earn students a maximum of 4 points for each question, although students may get 1, 2, or 3 points, depending on how many parts of the question they answer. The first year that MCAS was administered, many ELL students read the questions, found them confusing, and left them blank, earning an automatic zero.

As literacy specialists, Dianne and I realized that we needed to teach students how to read these questions and write the answers so that they could demonstrate their mathematical understanding. Therefore, we reviewed all the open-response questions on past MCAS tests and studied the answers of students who scored a 4—the maximum points possible. (Test answers are provided by the Massachusetts Department of Education on their Web site at <http://www.doe.mass.edu/mcas/>.) We determined that students need to read

and understand three types of vocabulary: math vocabulary (e.g., square yard, circumference, symmetry, integers), procedural vocabulary that tells students what to do (e.g., sketch a graph, explain, calculate, show your work), and descriptive vocabulary that test writers use to provide the context for the math problems (e.g., installation, granola bars, cinnamon, amusement park). We also learned that students need to know strategies that can help them read the complex questions that often appear in word problems. These multi-step questions ask students to demonstrate and apply their mathematical understanding, often combining several math skills. Finally, they need to know how to show their work on open-response questions in order to get full credit. For example, in questions that say, “Show your work *or* explain your answer,” students need to know that “show your work” means that if they label all their work, show the steps they used to solve the problem, make a table, if appropriate, and clearly identify their answer, they will get full credit; that way, they don’t even have to write complete sentences! This is critical for ELL students who have a good understanding of math concepts, but don’t have English academic math vocabulary. Given this, we recognized that students need to be able to apply certain literacy techniques in answering open-response questions on the math MCAS test. Collaborating with the math teachers in our school, we developed a series of lessons to help ELL and standard curriculum students improve their mathematical literacy.

Improving ELL Students’ Mathematical Literacy

These lessons took place in the standard curriculum math classrooms on a fairly regular basis—weekly in grade six and monthly in grade eight from January to May. They were designed to reinforce a math concept and give students experience with reading and answering MCAS open-response questions. The math teacher and literacy specialist chose a question from a previous MCAS test that related to a math concept the

students were currently studying. The literacy specialist would then teach students how to read the question, identify what it was asking, and prepare an adequate answer. The math teacher was always present in class, ready to work with students and clarify questions about math concepts. In addition to providing this instruction in the general math class, literacy specialists also taught students in the ELL support class. There, we were able to go over the problems more slowly, reinforcing math and literacy skills. On the sixth-grade team, where ELL students are integrated into the math class, Dianne worked with Carolyn, the ELL teacher, to preview vocabulary on the open-response questions before students practiced the question in their math class. Previewing the vocabulary helped students participate more in the general math class when their teacher went over those problems the next day. This provided extra support for the ELL students in an environment where it was safe to ask any math or reading question.

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Our Program

As literacy specialists, we designed our class to meet three goals:

- Teach students to recognize the types of vocabulary used in math questions and reinforce math vocabulary;
- Provide students with strategies for reading the questions and identifying what they need to do;
- Give students practice “explaining their thinking or showing their work.”

Whether we were working in the general math class or the ELL support class, our instruction was designed to give the students the skills and practice they needed to feel confident when reading and answering MCAS questions.

Teaching Vocabulary

Literacy specialists have worked hard in our school to support vocabulary development in all content areas, so we are fortunate that most of the math teachers in our school create word walls, posting academic math vocabulary on the walls where students can refer to it. Word walls help middle school students see that math has a very specific language. Math teachers reviewed the Massachusetts Math Frameworks while we reviewed the MCAS test to

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make sure that we were using the math vocabulary students were expected to know. Math teachers also began to encourage students to label all their answers so that they would be familiar with saying, writing, and reading

words like *square feet*, *calculations*, and *equation*. Further, in our Connected Math Program, which is used in grades 6 and 7, students write math reflections where they describe their understanding of concepts such as interior angles, finding the area of a polygon, and positive and negative integers. This writing helps students develop and practice their math vocabulary.

To support student learning of procedural and descriptive vocabulary, Dianne and I worked on problems from the MCAS test with students during math class. After the first year of the MCAS test, when ELL students were unable to answer a question about circle graphs because they did not know the word *sketch*, we realized that we also need to teach students procedural words as well as how to deal with descriptive words that are not essential for solving the math problems. We now teach students the meanings of words like *estimate*, *compare*, *compute*, *describe*, and *sketch*. We then provide questions that use test vocabulary with simple numbers. For example, one of the open-response questions on the sixth-grade MCAS test requires students to make a table, write an expression using a variable, and make calculations. As a practice exercise, Dianne created a question about the Boston Red Sox and the New York Yankee base-

ball teams that required students to perform the same math tasks—make a table, write an expression using a variable, and make calculations using simple numbers. This problem was presented as a class activity, and students were invited to identify the math vocabulary and discuss the procedural vocabulary. In this way, we made sure that students were familiar with the language of the MCAS questions. Then students were asked to solve independently an MCAS open-response problem that used the same language but had more complex numbers. The analysis of the language used in the question enabled students to feel more comfortable solving the MCAS problem.

While the academic math vocabulary and most of the procedural vocabulary is described in our Massachusetts Math Frameworks, we realize that we cannot teach the students all the descriptive words they need to know. So, we teach them strategies for solving math problems if they don't know all the words. For students who are new to American culture, words like *granola bars*, *carpet*, *bounce*, and *balloons*, which are meant to make a question interesting but are not essential to its resolution, may be unfamiliar. Working with a group of eighth graders, we learned that sometimes you can answer a question like, "Make a bar graph that shows the number of granola bars each student ate," even if you don't know what the word *granola bars* means. Students covered up the words *granola bars* and realized that if they understood that the question was asking them to compare quantities by making a graph, they could answer it anyway. Similarly, when a question asks about "a box of granola bars," they can skip the word *granola* and still solve the problem. This strategy empowers students. They realize they don't have to skip a question just because they don't understand every word. To reinforce this concept, we practiced reading problems and crossing out any words that were unnecessary to solve the problem. We also suggested students look for cognates—words that use the same Latin base so have a similar meaning in English and other languages. This activity helps students realize the importance of knowing math vocabulary: they might need to know words like

stem-and-leaf plot, circumference, or equation, but at least they have been empowered with the knowledge that they didn't have to know every English word.

Teaching Strategies for Reading the Question

Through our practice sessions, we taught students how to read mathematical problems, and then how to break them down into small, manageable parts. Although the students were doubtful at first, Lori kept telling them, "The question is your friend. It has the information you need to solve the problem." We reminded students to pay attention to the units of measure so that they would know if they needed to do any conversions, such as changing feet to yards, and so they could accurately label their responses. Since many questions require students to work through a progression of mathematical steps, we taught students to read the questions at least twice so they understood what was being asked and wouldn't miss anything. We also taught students to use objects to visualize what a question was asking. For example, if a problem included a square that measured 12 in. x 12 in., Dianne would make the square out of poster board so that students could see the size. If a problem asked for the perimeter of a fence, we would have students draw a fence, writing in the measurements. We also taught students to create a table out of the information to help clarify what was being asked. These strategies helped students realize that they had to read actively, thinking about each part of the problem, even if the problem was only a few sentences.

Teaching Students to Respond to Open-Response Questions

In our practice sessions, we taught students how to write responses. We pointed out that many problems ask students to "Show your work or explain your thinking." This, we explained, gave students an option that didn't require sentences as long as all of their calculations were clearly structured and labeled. After students responded, we displayed other solutions using the overhead pro-

jector: first those that had earned a score of four, then three, then two, then one. (Massachusetts Department of Education releases responses to open-response questions on their Web site so that students can see models of each score.) By viewing examples of other students' responses, students were able to understand what a complete answer looks like. We emphasized that if a question had parts, and they only knew the answer to part A, they should write that as clearly as they could, and try the other parts. We gave the students the option to work alone or together to identify why the answers received each score, and then asked them to score their own work.

Effects of Setting

One of the most effective aspects of our work took place in ESL support classrooms, where 16 students had the attention of two teachers (as opposed to an average of 27 students and one teacher in the standard math classes). Here, we could work with students individually, answering language- or math-specific questions more slowly to ensure that students really understood each step. Moving frequently from country to country or city to city, ELL students may miss critical math skills, but in this setting, students feel comfortable asking questions about basic math concepts and even help each other, gaining knowledge and confidence. In one case, after a conference with the sixth-grade math teacher, Dianne previewed the open-response questions with students in the ELL setting before she taught the question in the larger setting. This enabled the ELL students to participate more in the standard curriculum math class.

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Results

In March of 2003, a law was passed in Massachusetts that requires all students to take the MCAS test in English. We cannot even imagine what it

must be like for a student who has only been in this country for three months to take a challenging academic math test in a new language. However, our MCAS data shows that more sixth-grade ELL students tried to answer the open-response questions in 2003 than in 2002. Teachers who observed the test reported that students did try to answer questions and fewer appeared to give up in frustration. They also reported that their own work with the literacy specialist to analyze math questions provided them with strategies to support students with the language of mathematics.

When students were asked to describe how they felt after taking the MCAS, they reported that they felt prepared. One sixth-grade student wrote, “Ms. Rappaport [math teacher], I feel great. I did not freeze like in big tests or quizzes. I want to thank you and Ms. Fleming for helping. I have a feeling I am going to pass.” Another student wrote, “I think I was prepared. Most of the questions were pretty easy. And I didn’t feel nervous or scared.” One other sixth-grader reported, “I felt very nervous at first, but then in the second section I felt more [sic] better and happy cause I knew more answers to the questions. The things that Mrs. Fleming taught us were very helpful.” Eighth-grade students, who received the open-response preparation only two or three times before the MCAS test, responded that the sessions helped them to analyze the questions. One student replied, “Mrs. DiGisi showed us how to interpret the questions and the vocabulary in the questions. She helped us to organize the open-response question.” Another student wrote, “Mrs. DiGisi helped me [know] how to outline the question, label, and break down the question to make it be [sic] easy for me. For example, the question is my friend and you have to read the question twice.” Eighth-grade students also reported that they felt more comfortable answering the open-response questions in the ELL setting.

Importance of Support for the ELL Student

In conclusion, all of our students, but particularly the ELL students, appreciate support in learning how to read and write responses to open-response questions. Statewide assessments pose questions that may require students to read critically, analyze, and solve using several steps. Practice and review with procedural and academic math vocabulary, strategies for identifying descriptive vocabulary that is not essential to answering the question, strategies for reading the question and identifying the required calculations and format, and practice “explaining their thinking or showing their work” all help students enter the MCAS test feeling prepared and confident. This enables them to do the kind of challenging mathematical thinking that is required to solve these problems. For ELL students who may not have as much experience with standardized tests, or the language of these tests, a supportive setting becomes a safe place to ask the questions they need to ask, to learn the math that they may have missed along the way, and to practice with the language that they need to be successful. These sessions, co-taught by a literacy specialist and a math teacher, enabled most of our students to feel like the sixth grader who wrote, “I think I was prepared. Most of the questions were pretty easy. And I didn’t feel nervous or scared.”

[AUTHORS’ NOTE: The authors would like to thank the math and ELL teachers at Fuller Middle School who collaborated with them in the work described in this article. They would also like to thank Dr. Carol Bearse, the Bilingual Curriculum Coordinator and Literacy Specialist, for keeping us aware of the needs of ELL students and for sharing her expertise with us.]

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